Canalization of sub-wavelength images by electromagnetic crystal

C. R. Simovski, P. A. Belov, S.I. Maslovski, P. Ikonen and S.A. Tretyakov
Radio Laboratory /SMARAD, Helsinki University of Technology

The original regime of operation for some flat superlenses formed by a layer of an electromagnetic crystal is proposed and studied theoretically. Both analytical modelling and FDTD simulations are applied. The mechanism does not involve negative refraction and amplification of evenescent waves as it was suggested in many previous works devoted to slabs of left-handed media. The high-frequency (sub-wavelength) spatial spectrum of a source is canalized together with the plane-wave spectrum by the eigenmodes of the crystal. All eigenmodes have equivalent longitudinal (i.e. directed across the slab) components of the wave vector and equivalent group velocities (which are also practically longitudinal). When the normalized frequency is moderate (the wavelength is large with respect to the crystal period) this regime can be obtained with the use of semiconductor crystals. For the TE-polarization this can be a lattice of air holes in a semiconductor matrix. For the TM-case this can be a lattice of semiconductor rods. The regime can be implemented at the low normalized frequencies with the help of impedance cylinders (at microwaves these cylinders form capacitively loaded wire media) or even with simple metal cylinders. The resolution of the order wavelength/6 is demonstrated. The thickness of the superlens is not related with the distance to the source and the lens can be made thick enough to be mechanically stable. Possible applications in the near-field optical microscopy are discussed.